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DATA TRANSMISSION EQUIPMENT,(U)

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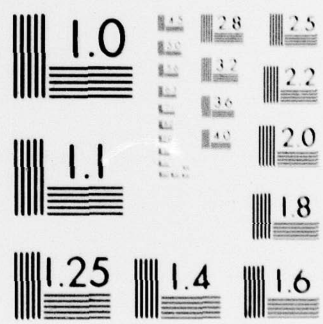

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FOREIGN TECHNOLOGY DIVISION

AIR FORCE SYSTEMS COMMAND

DATA TRANSMISSION EQUIPMENT

BY

V.I. Denisov, V.A. Pavlov

FOREIGN TECHNOLOGY DIVISION

EDITED TRANSLATION

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DATA TRANSMISSION EQUIPMENT

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Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

DATA TRANSMISSION EQUIPMENT

V. I. Denisov, Chief Engineer of the VTs Gor'kovskaya Doroga,

V. A. Pavlov, Assistant Chief of the Communications Branch

Contemporary computers ensure accuracy of processing information with an error probability in the binary symbol not greater than 10^{-6}-10^{-8}. The probability of errors occurring with the transmission of data along telephone or telegraph communications channels is within 10^{-4}-10^{-5}. As a result of this, the accuracy of calculations of problems on a computer with the use of communications channels in the control system or data processing can be achieved only with the aid of special measures which increase the life of information transmission by at least 2-3 orders.

The high speeds of information processing in a computer, and also the necessity in many cases to process information practically in a real scale of time, limits the possibilities of using unautomated methods of preventing errors. In contemporary data transmission systems, automatic devices for increasing the reliability of information are used.

Russian industry has assimilated the series output of data transmission equipment with automatic devices for increasing the reliability of information.

Let us examine two types of equipment: the low-speed "Akkord-50 PP" and the medium-speed "Akkord-1200 PP".

APD [data transmission equipment] "Akkord-50 PP"

This equipment is designed for operation in a network of commutating telegraph channels of a user's telegraph up to a speed of 50 bauds. With the presence of a communications channel with corresponding parameters, operation with a speed of up to 100 bauds is possible.

Reliability increases as a result of the fact that the quality of transmission along a communications channel is controlled by the equipment, and errors which occur are detected with the aid of a cyclic code and are improved with repetition. We use in the equipment a method of information transmission with solving reverse communications.

The equipment consists of a stand for the receiver-transmitter "Akkord-50 PP" and the SU conjugating device. As the input and output devices we use the FS-1500 photoreader (article of the ChSSR) and the PL-150 tape perforator. For calling the required user, we use the VP calling instrument. An external view of the equipment is shown in Figure 1. The digits on it indicate: 1 - receiver-transmitter; 2 - conjugating device; 3 - FS-1500; 4 - PL-150; 5 - telegraph equipment; 6 - VP calling instrument.

The "Akkord-50 PP" can operate in a semi-duplex along double-conducting lines in conditions with a fixed length of the block (FDB) and with a free length of the block (SDB) with a speed of transmission of 50 or 100 bauds. Codes: five-element MTK-2 and the eight-element GOST 13052-67, information carrier - punched tape. Input directly from the telegraph equipment is possible.

Relative distortion with transmission: to the side of the line - 5%, to the side of the output devices - 20%; correcting ability of the receiver - no worse than 45%;

reliability of information - no worse than 1 sign per $3 \cdot 10^6$ of correctly accepted signs (in the FDB mode);

input and output of information - parallel or sequential;

method for detecting errors - coding of the constant length block (in the FDB mode), coding of the changing length block (in the SDB mode) and decoding with reception;

method for correcting errors - automatic repetition of blocks of data accepted with errors (FDB mode), transfer to mode of user telegraphing (AT) with detection of error in the block (SDB mode);

length of the block: in the FDB mode - 60 elements (15 start-stop signs), in the SDB mode - up to 325 elements (up to 65 start-stop signs);

noise-suppressing code - cyclic;

linear voltage - ±60 V;

voltage of the feed network - alternating 220 V, frequency 50±2 Hz; required power 250 VA;

reliability indicator $T_{[illegible]}$ =626 h; average time for establishing readiness of the equipment - 30 min.

A diagram of the data transmission tract along the network of the user telegraph is given in Figure 2.

For transmission of data between two points, two equipment complexes of user telegraph terminals are required. After establishing a connection of the equipment, we switch to a mode of transmission or reception of data. The transmitted information is preliminarily carried on 5- or 8-track punched tape, and then input into the equipment with the aid of an input device.

As the input device we use the photoreading device FS-1500. The input of information from the keyboard of the telegraph equipment is possible. The accepted information is taken from the communications channel to the tape puncher PL-150 or the reading device of the telegraph equipment.

The transmitting station, on the signal "data transmission", reads information from the input device, which then proceeds to the communications channel and to the decoder, accomplishing noise-suppressing coding, and stores it in the memory. Information from the input device is read unit-by-unit. The structure of the data blocks for modes FDB and SDB is given in Figures 3 and 4.

At the receiving station, the data blocks proceed to the decoder which detects errors, and are recorded in the memory. If no errors are detected in the data block, then information is taken from the memory to the output device, and the signal "receipt", advising the transmitter of error-less reception of the data block, is sent along the reverse channel to the side of the transmitting station. The transmitter, having received the signal "receipt", erases the signal recorded in the memory of the data block, reads the new data block from the input device, and repeats the cycle. In the case of detection of an error, the decoder gives out a signal which prohibits the output of a data block from the memory to the output device.

The absence of the "receipt" signal for 1.5 seconds after transmission of a data block, as with its distortion, is considered as a signal "inquiry of a distorted data block". In this case, the transmitting station does not take a new data block from the input device, but gives off information to the decoder and the communications channel from the memory.

The reliability of the transmitted information with this method of transmission is determined by the degree of detection of error, ensured by the selected code.

For constructing the cyclic codes we use the writing of code combinations:

$$G(x) = a_{n-1}x^{n-1} + a_{n-2}x^{n-2} + \ldots a_1x + a_0.$$

where a_i - coefficient of scale of notation,

x - basis of the scale of notation.

The cyclic codes are formed by multiplying each code combination expressed in the form of a polynomial G (x) on the forming polynomial P (x) by degree (n-k),

where n - total number of symbols of the correcting code,

k - number of information elements in the code combinations.

As a result of multiplying by the forming polynomial, the number of permitted code combinations does not change, but remains equal to 2^k, and the total number of prohibited coded combinations is equal to 2^n-2^k. The permitted code combinations are distinguished by the fact that they are all divided without remainders by the forming polynomial P (x). With division of any prohibited code combination by the forming polynomial, remainders invariably occur. This property of the cyclic code is used for detecting errors which arise in communications channels under the influence of interference.

The detecting ability of the cyclic code is fully determined by the degree of the forming polynomical. In the equipment, the forming polynomial is used in the form:

$$P(x)=1+x+x^{3}+x^{6}+x^{12}+x^{13}$$

The cyclic code of the form given here permits detecting all errors up to a weight of 3 (i.e. 0, 1, 2, 3), all errors of uneven weight, and also all packets of errors with a length of up to 13 elements. The remaining errors are detected with a probability of:

$$P=1-2^{-13}.$$

With binomial distribution of errors and probability of distortion of the element in the channel of $P_{0}=1\cdot10^{-4}$, the cyclic code gives a probability of detecting an error in the block of $P_{0}^{н}\leq1\cdot10^{-8}$.

With operation of the equipment in the FDB mode, the time of transmission in comparison with the time of transmission of unprotected information increases no more than 20%; with operation in the SDB mode - no more than 10%.

<u>APD "Akkord-1200 PP"</u>

This is equipment for data transmission along two- and four-line telephone channels with standard width, organized according to air, cable, and radio-relay lines of communication.

The APD "Akkord-1200 PP" consists of a stand with a device for protection against errors (UZO) and an operator table. Placed on the operator table are "Modems" and devices for conjugating input and input devices (US). As the input and output devices we use photoreading device FS-1500 (article of the ChSSR) and the PL-150 perforator, installed on the operator's table. Moreover, placed on the table of the operator is the telephone equipment TA-65 ATS for operation along commutating channels, or an instrument for operation along separate channels (PVK).

An external view of the equipment is given in Figure 5. The numbers on it indicate: 1 - UZO; 2 - operator's table; 3 - PL-150; 4 - FS-1500; 5 - TA-65 ATS.

The APD "Akkord-1200 PP" can operate in a poliduplex mode with a double-line terminal and a duplex mode with four-line terminal with a speed of 600 and 1200 bauds. Information is transmitted by a method with deciding reverse communication with a reliability no worse than 10^6 of a distorted sign from correctly accepted signs.

The information carrier - 5-, 6-, 7-, and 8-track punched tape, and its input and output - parallel or sequential;

method of detecting errors - formation and coding of blocks of constant length and decoding with reception; method of correcting errors - automatic repetition of data blocks accepted with errors; code - cyclic; correcting ability of the correction device - 40%;

length of the block - 260 elements with a speed of 1200 bauds and 132 elements with a speed of 600 bauds;

voltage of the feed network - alternating 220 V, frequency -

50 ± 2 Hz; required power - not more than 1000 VA.

The equipment occupies an area of no more than 5 m^2.

A block diagram of the tract for operation along commutatable and separate telephone channels is reflected in Figures 6 and 7.

For calling the users and establishing a connection with them along commutatable channels on the telephone equipment TA-65 ATS we select the number of the desired user, and with operation along separate telephone channels on the instrument PVK - press the "call" button.

With data transmission, the telephone channel, with the aid of spectrum frequency separation, is divided into a data transmission channel (direct channel) and a channel for transmitting function signals (reverse channel).

The operating frequencies of the direct and reverse channels are shown in the table.

Before beginning data transmission, the receiving station is phased relative to the transmitter according to transmitters and cycles. The transmitting station forms a combination of phasing, which directly proceeds to the communications channel before acquisition, along the reverse channel, of a signal "confirmation" from the receiving station. The receiving station conducts a continuous search for the combination of phasing in sequence, in which the signals proceed from the communications channel and, as it can only be found, the signal "confirmation" is sent along the reverse channel.

With the acquisition of the signal "confirmation" at the transmitting station, data are read in the parallel code of the photoreading device FS-1500 and proceed to the UZO, where they are converted to sequential code and divided into blocks. The structure of a block is shown in Figure 8. Indicated on it are: 260/132 element - full length of the block at a speed of 1200/600 bauds; 4 - element - unction sign of the block (A, B, C); 240/112 elements - information part of the block at a speed of 1200/600 bauds; 16 - elements - checking part of the block.

The formed blocks of data in sequential code proceed to "Modem". "Modem" converts the sequence of pulses to frequency-modulated oscillations and separates them into the channel.

The data blocks are simultaneously recorded in the memory of the transmitting station without a checking combination. The transmitter's memory is calculated for simultaneous storage of two data blocks.

The transmitting station continuously transmits data blocks to the communications channel and analyzes the signals of the receiving station on the reverse channel.

With the acquisition of the signal "confirmation", the transmitter transmits the next data block to the channel, and from the input device a new block is read. With the acquisition in the reverse channel of the signal "inquiry", two data blocks are transmitted from the memory to the communications channel; here data from the input device are not read.

At the receiving station, the frequency-modulated signals are detected and, in the form of a sequence of pulses, proceed to the decoder and, simultaneously, to the memory, designed for storing one data block. If no errors are detected in the data block, the data from the memory are separated to the perforating device P1-150.

The signal "confirmation" is simultaneously sent along the reverse channel to the side of the transmitting station. With the detection of an error in the data block, the latter are not separated from the memory, and the signal "inquiry" is transmitted along the reverse channel.

For eliminating loss or the acceptance of two identical data blocks as a result of distortions in the reverse channel or repeated inquiries, data blocks are numbered at the transmitting station. They follow with the function signs (A, B, C, A, B, C, ... etc.).

The numbers of the data blocks are also recorded in the memory of the transmitting station. Therefore, the number assigned to the block remains with it until such time as the block will not be accepted correctly.

The receiving station continuously analyzes the order of procession of function signs of the data blocks and with its distortion separates the equipment from a data transmission mode to a "telephone" mode. The switching of equipment to the given mode occurs only after acquiring the signal "confirmation" to the last transmitted block with the sign "end transmission". The light signal "end transmission" is lit simultaneously on the panel of the UZO and on the operator's table.

A block with the function sign "end transmission" proceeds to the receiving station after finishing the transmission of data. With the decoding of this sign, the signal "end transmission" forms at the receiving station.

However, disengaging the equipment from the communications channel occurs only with removal of the "carrier" at the transmitting station.

With the necessity to interrupt data transmission for function calls, the operator of any station can switch the wquipment to a telephone mode by pressing the key on the operator's panel and, after finishing the calls, continue the transmission without loss or duplication of the data blocks.

The examined equipment of data transmission "Akkord-50" can be used on railray transport for protecting telegraph communications channels with the transmission of reliable information from linear subunits on the road to the computer center.

The equipment for data transmission "Akkord-1200 PP" can be installed in directions which have greater volumes of information. With the aid of this apparatus, we can organize systems of data transmission both with commutation of channels and with commutation of messages.

Figure 1. Data transmission equipment "Akkord-50 PP".

Figure 2. Diagram of the data transmission tract with respect to the user telegraph circuit. Key: 1 - user point A; 2 - communication line; 3 - user point B; 4 - FS-1500; 5 - PL-150; 6 - SU; 7 - Akkord-50 PP; 8 - RTA; 9 - VP; 10 - Automatic telegraph station; 11 - communication channel.

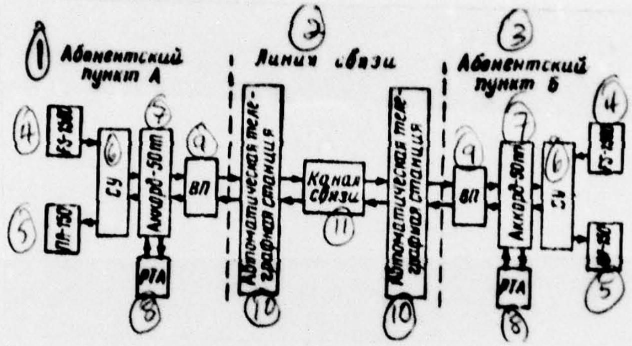

Figure 3. Data block for FDB mode. Key: 1 - start; 2 - stop; 3 - two function digits; 4 - 12 start-stop signs (60 digits) ; 5 - 13 control digits.

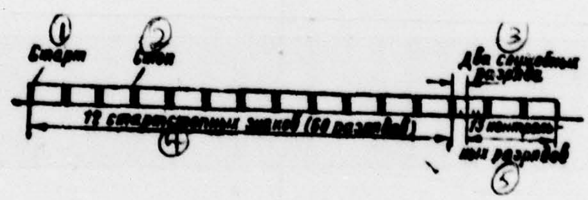

Figure 4. Data block for SDB mode. Key: 1 - combination of transfer of line; 2 - start; 3 - stop; 4 - combination of reset of short; 5 - two function digits; 6 - up to 65 start-stop signs; 7 - 13 control digits.

Figure 5. Data transmission apparatus "Akkord-1200 PP".

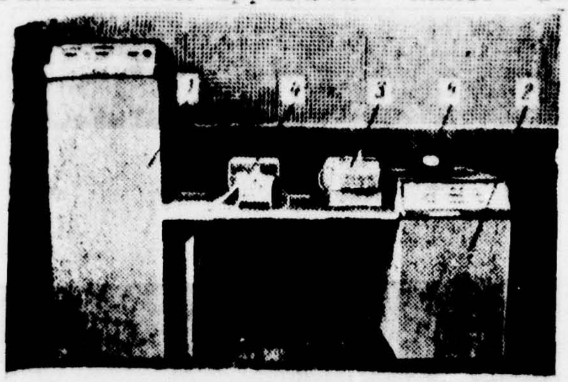

Figure 6. Block diagram of the tract for operation along commutatable telephone channels. Key: 1 - user point A; 2 - receiver-transmitter; 3 - operator's table; 4 - UZO; 5 - US; 6 - Modem; 7 - TA; 8 - MATS; 9 - communication line; 10 - channel for telephone communication; 11 - user point B; 12 - FS-1500; 13 - PL-150.

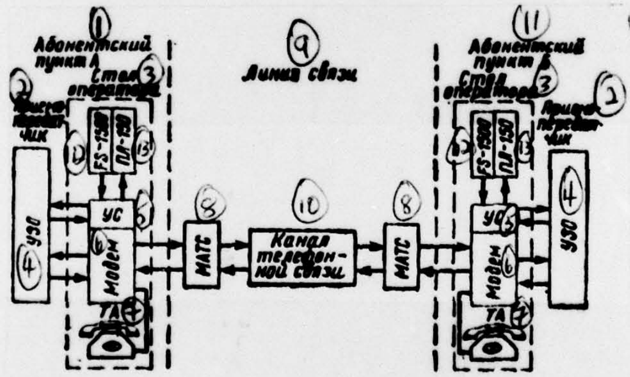

Table. Key: 1 - Speed, bauds; 2 - low typical frequency, Hz; 3 - carrier frequency, Hz; 4 - upper typical frequency, Hz; 5 - Deviation of frequency, Hz; 6 - direct channel; 7 - reverse channel.

(1) Скорость, бод	(2) Нижняя характеристическая частота, Гц	(3) Несущая частота, Гц	(4) Верхняя характеристическая частота, Гц	(5) Девиация частоты, Гц
Прямой канал (6)				
600	1300 ± 10	1500 ± 10	1700 ± 10	± 200 ± 10
1200	1300 ± 10	1700 ± 10	2100 ± 10	± 400 ± 10
Обратный канал (7)				
75	390 ± 2	420 ± 2	450 ± 2	± 30 ± 2

Figure 7. Block diagram of the tract for operation along separate telephone channels. Key: 1 - user point A; 2 - operator's table; 3 - receiver-transmitter; 4 - FS-1500; 5 - PL-150; 6 - US; 7 - UZO; 8 - Modem; 9 - PVK; 10 - communication line; 11 - telephone communication channel.

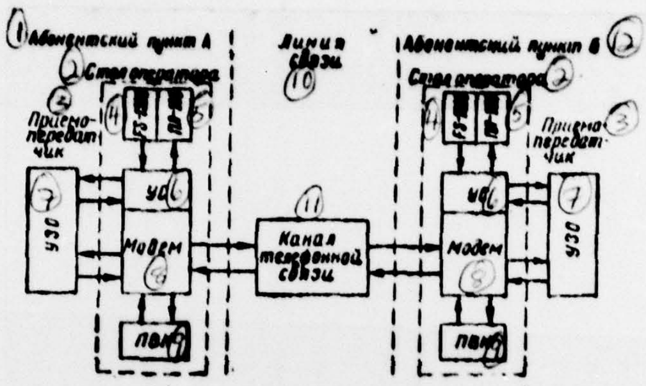

Figure 8. Structure of an information block. Key: 1 - 4 elements; 2 - 240/112 elements; 3 - 16 elements; 4 - 260/132 elements.

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